(12) UK Patent Application (19) GB (11) 2 326 002 (13) A

(43) Date of A Publication 09.12.1998

(21) Application No 9711598.8

(22) Date of Filing 06.06.1997

(71) Applicant(s)
Centrepoint Technology Limited
(Incorporated in Hong Kong)
406 Alliance Building, 130-136 Connaught Road, Central, Hong Kong

(72) Inventor(s)
Ian John Dilworth

(74) Agent and/or Address for Service
Dummett Copp
25 The Square, Martlesham Heath, IPSWICH, Suffolk, IP5 3SL, United Kingdom

(51) INT CL[6]
G08C 17/02 , H04Q 9/00

(52) UK CL (Edition P)
G4H HNEE HNNA H13D H14A H14D H14G H60
U1S S2078 S2148 S2159 S2166 S2175 S2177 S2179 S2423

(56) Documents Cited

GB 2273593 A	GB 1384596 A	GB 1381734 A
GB 1343759 A	WO 93/04451 A1	WO 87/04275 A1
US 5617084 A	US 5583492 A	

(58) Field of Search
UK CL (Edition P) G4H HNEC HNEE HNEL HNEM HNHE HNNA
INT CL[6] G08C , H04Q

(54) Abstract Title
Remote reading of meters and sensors

(57) For the remote reading of e.g. a utility meter 12 within a meter pit 14 in the ground 16, a radio communication device 18 has a cover plate 20 for covering the pit 14, the cover plate 20 having: at least one antenna 22 for radio communication of meter readings from the meter 12 to a remote reading unit; and a battery 50 for supplying power to a radio transceiver.

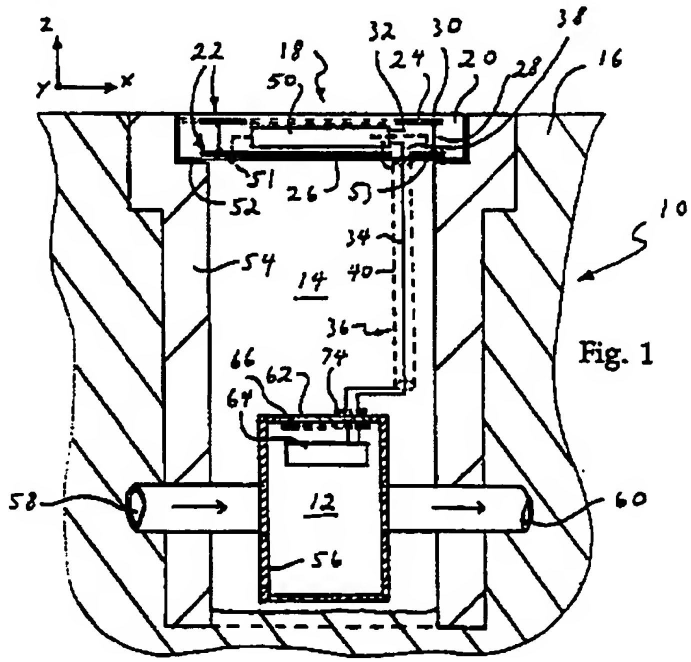

Fig. 1

GB 2 326 002 A

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1995

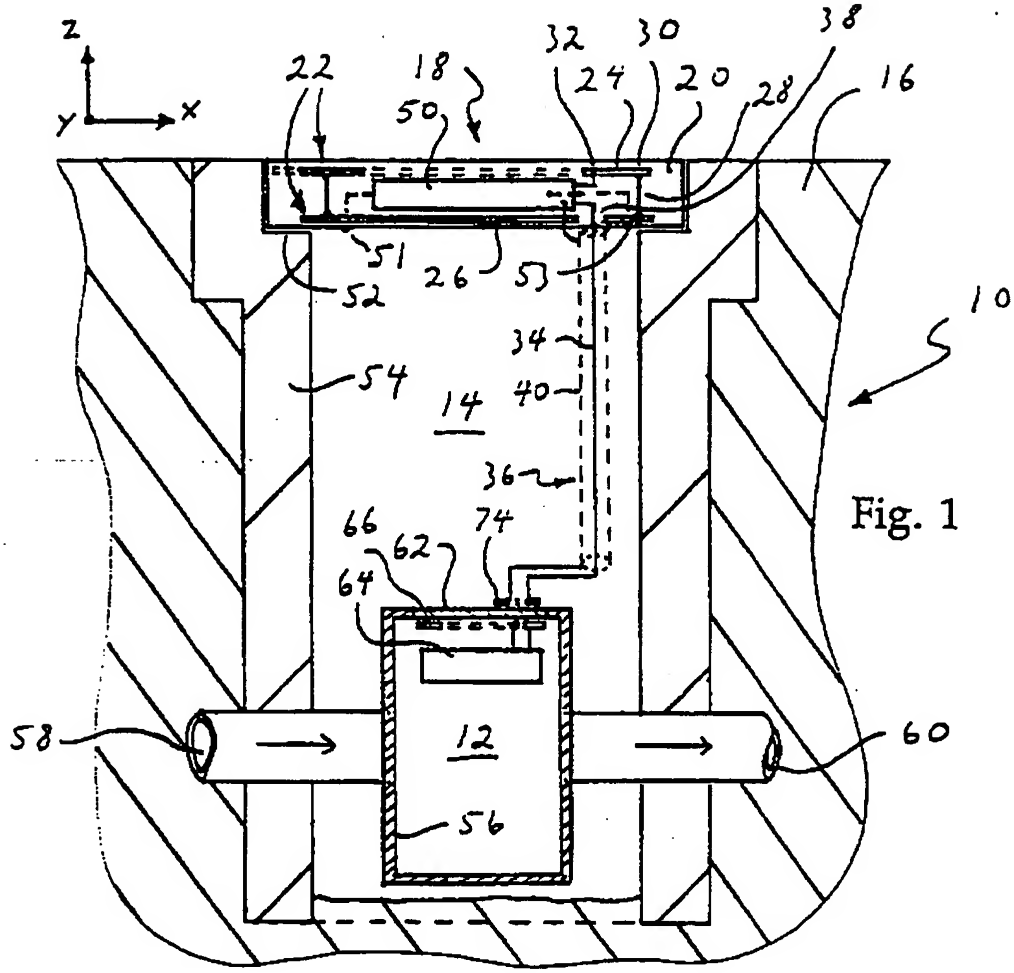
Z
Y
X
22
18
50
32
24
30
20
28
38
16
51
26
53
52
10
34
40
54
14
36
66
62
74
64
58
12
60
56

Fig. 1

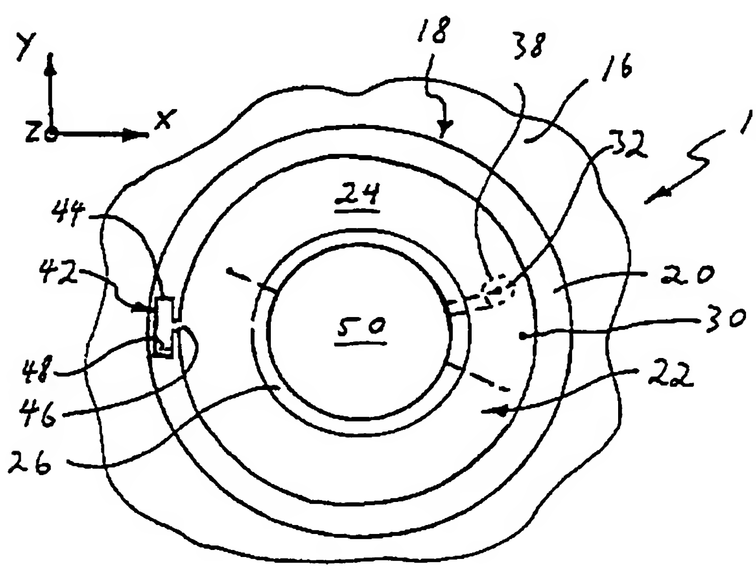
Y
Z
X
18
38
16
10
32
24
44
42
48
46
26
50
20
30
22

Fig. 2

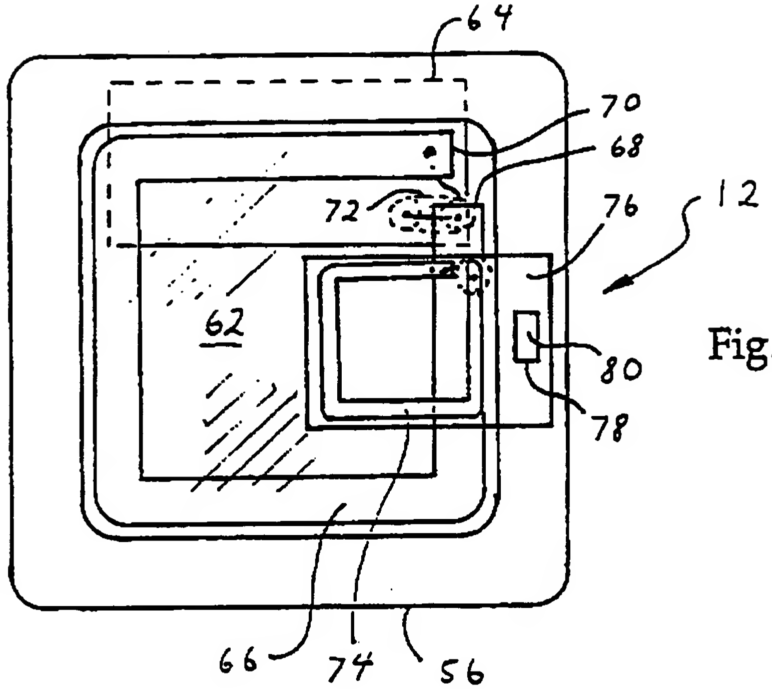

Fig. 3

2326002

Remote Meter Reading

The present invention relates to the remote reading of a meter or other sensor, and in particular a meter within a meter pit in the ground.

Meters or sensors may be housed in a recess in the ground called a meter pit, which is situated at or near a utility conduit, for example a water pipe or electrical power line. A meter may be an electricity, water or gas meter for measuring the amount of consumption of the utility. Sensors, for example voltage, temperature, pH or chemical sensors may also be used in conjunction with utility conduits to measure other parameters of the utility supply. The recess may have sides lined with concrete, but will have an access cover, allowing access to the meter or sensor, the cover being essentially at the level of the surrounding ground. Sometimes, as with water meters, the meter pit may be open at the bottom to allow surface water seeping into the pit, or ground water rising into the pit, to drain away during dry conditions.

In colder climates, the depth of the pit may be chosen so that the meter is below an expected frost line in mid-winter. In the UK, this depth is usually around 600 mm below ground level. The access cover is normally a protective lid or meter cover plate, which is often either square and hinged along one edge, or disc-shaped with a screw or bayonet fitting with a matching receptacle at the top of the recess.

Compared with other types of utility cover plate, for example a man-hole cover plate, meter or sensor access covers are generally quite small and light, for example of the of the order of 100 mm across and under 1 kg mass.

Therefore, the access cover plate may have means for locking the cover over the recess, for example with a key, so that the cover plate may not be readily opened or removed from the recess without the key.

Preferably, meters should be read monthly by the utility company providing the utility service, both so that customers get accurate billings and so that the utility company can quickly spot and repair any fault, such as an underground leaks in a nearby water main. Sensors may ideally need to be read even more frequently. It is, however, relatively inconvenient and expensive to have to read meters or sensors manually. As a result utility companies may have to rely on periodic sensor readings, or make estimated meter readings, the accuracy of which cannot be guaranteed. Actual readings may be taken relatively infrequently, for example twice or four times a year.

Ideally, it would be useful for a utility company to be able to obtain meter or sensor readings more frequently than once per month, for example to help in forecasting short-term demand for the utility service, or to detect faults in the supply more rapidly.

For simplicity, the terms "meter" and "metering" will hereinafter encompass respectively the terms "sensor" and "sensing".

It is an object of the present invention to provide a radio communication device and a utility metering device to reduce some of the problems associated with manual readings of meters.

Accordingly, the invention provides a radio communication

device for remote reading of a meter, comprising a cover plate for covering a recess in which the meter may be held, the cover plate having: at least one antenna for radio communication of meter readings from the meter to a remote reading unit; and a battery for supplying power to a radio transceiver.

Also according to the invention, there is provided a utility metering device that may be read remotely, comprising a utility meter for installation in a recess, and a radio communication device having a cover plate for covering the recess, the cover plate having: at least one antenna for radio communication of meter readings from the meter to a remote reading unit; and a battery for supplying power to a radio transceiver, the radio communication device being arranged to communicate meter readings from the meter to the remote unit.

The term "transceiver" as used herein includes devices which may transmit and/or receive radio signals.

The meter may be a flow meter for measuring water consumption, or any other type of utility meter.

The radio communication device may also have a cover plate which comprises a radio transceiver. This has the advantage that the radio transceiver may be conveniently powered by the battery without the need to run any wiring external of the plate, and also be protected by the cover plate.

The use of a battery avoids the need to run an electric power source to each meter site. The battery may also power any other circuitry associated with the antenna or meter. Although the battery could be sited anywhere in

the recess, it is particularly advantageous that the battery be protected and/or removable with the access cover comprising the battery. Since the recess will most commonly be in the ground, the cover will be at the highest portion of the recess, and the elevated position of the battery will help prevent any water in the recess from adversely affecting the battery.

The battery may be rechargeable or non-rechargeable. In the latter case, changing the battery may be accomplished by changing the cover. In the case of a rechargeable battery, it may still be desirable to remove and change the cover so that the battery may be recharged, for example, at a remote location. However, in one embodiment, the battery may be recharged by incorporating one or more solar cells within the cover plate, and using these to recharge the battery. The solar cells may be encapsulated within the cover plate, which would then have a light transmissive portion aligned with the cell or cells so that sunlight may charge the cells.

The antenna may be housed inside the cover plate or may be flush with a surface on the cover plate. Preferably, the antenna, and optionally also any transceiver circuitry, is encapsulated within the cover plate so that the antenna, and transceiver, is protected from the external environment.

Preferably, the battery is encapsulated within the cover plate so that the battery is protected from the external environment.

The remote unit may be a hand held unit which is carried by meter reading personnel to the vicinity of the meter or a number of meters. However, in order to automate a

meter reading system it is advantageous if the remote unit is part of a base station, preferably a fixed base station which may be in communication with a large number of meters, for example of the order of 1000 to 10,000 meters within a given district of a city or county.

Meter readings may be transmitted from the antenna to the remote unit in any number of known data transmission formats for example a digital format, which may be encoded by pulse width modulation (PWM) or pulse position modulation (PPM), either at single frequency or in spread spectrum mode. Transmission frequencies may be of the order of 100 MHz to 5 GHz.

In many cases, it will be desirable if radio signals may be received as well as transmitted. For example, a base station may individually poll each utility meter site assigned to a base station, the polling signal containing a unique address identification signal specific to one site. The polling signal may then initiate a meter reading and transmission of a meter reading from the antenna in the cover plate to the base station. It would be possible to have a separate antenna for reception and transmission of meter readings, but preferably one antenna may be used for both reception and transmission.

Data transmitted from the meter reading unit to the base station may comprise data other than that from the meter, for example data comprising information regarding the amount of charge still held by the battery.

Electronics associated with transmission, reception or meter reading circuitry may be built into the cover plate, rather than being incorporated with a utility meter. This has the advantage that if improvements or alterations need

to be made to the remote meter reading system, or if the electronics need to be serviced, this may be effected by replacing the electronics or the cover plate, rather than the utility meter itself. This avoids the need to disconnect the meter and interrupt the supply of the utility service. There is the further advantage that components encapsulated within the cover plate may be effectively protected from the elements and from water flooding the meter pit.

It would be possible to devise a system not reliant upon receipt of a polling signal, for example if an electronic clock is incorporated with meter reading circuitry. Meter readings may then be taken and transmitted from the antenna at predetermined intervals. It may therefore not be necessary in some cases for the antenna and any associated circuitry to be able to receive radio signals, just that this must be able to transmit radio signals.

Although power requirements and radio interference from a number of meters may make it impractical for the meter to transmit continuously, if the meter has a clock or if it transmits at a predetermined time for example when meter reading reaches a predetermined value, then the meter may transmit without the need for receiving a polling signal

Since the meter may be sited outdoors, in order to provide additional protection for the meter, particularly from the ingress of water, the cover plate may have means for sealingly covering the recess, for example having an O-ring seal.

For an electricity meter, the radio communication device may have a ready source of electrical power upon which to

draw for its operation, and so may not need a battery. With other types of meter, such as natural gas or water meters, it may still be possible to draw some energy from the meter, for example by a vane rotated by fluid flow driving a miniature electrical generator to charge the battery. Such a rechargeable battery may then supply enough current to operate the radio communication device, at least intermittently, even if the power output of the miniature generator is relatively small.

It may be desirable to make the battery as large as possible to provide the maximum number of milliamp-hours of battery capacity. Therefore, when the battery is incorporated within the volume of the cover plate, the antenna may be disposed either to one side or, most preferably, around the battery.

The battery may be replaceable, but to minimise cost over the lifetime of the battery, is preferably rechargeable. The cover plate may therefore be removable from the meter recess so that the plate may be taken away, for example once every few years, so that the battery may be recharged. Since the battery may be protectively sealed within the cover plate, contacts for recharging battery may be provided on an outer surface of the cover plate, for example on a lower surface.

The performance of batteries is reduced by extreme cold. Therefore, the cover may comprise thermal insulation to thermally insulate the battery. Preferably, this insulation may be provided on just one side of the cover plate, which in use would be the uppermost side of the plate. This may be advantageous where the one insulated side of the cover is exposed to the elements, for example facing upwards towards the sky with the other side of the

cover facing down into the meter pit. The insulation may then prevent the battery from getting too cold, for example on clear winter nights when heat is radiated from the ground into the upper atmosphere. Since the meter pit will normally be deep enough so that the pit remains at or above freezing, the temperature of the battery may then be substantially insulated from ground frost by heat radiated within the meter pit.

The transmission and/or reception radiation pattern of the antenna may be directional, for example with the cover plate and antenna being aligned for communication with a particular base station. However, it is preferable if the antenna response pattern is substantially azimuthally omnidirectional, for example omnidirectional to within 3 dB. This has the advantage that the cover plate does not have to be azimuthally oriented so that the antenna response pattern is directed towards a base station.

It is advantageous if the antenna has a low profile, for example so that it is comparable in size to a flat disc-shaped cover plate. Various type of low-profile antenna may be employed, for example patch, loop, folded monopole or inverted-F antennas. In a preferred embodiment of the invention, the antenna is a slot antenna.

The term "slot antenna" is used herein to describe the type of antenna with a planar slot-ring of conducting material, which may be formed or plated on a substrate, mounted above and parallel to a ground plane, the "slot" being formed by the gap between the slot-ring and the ground plane. Such a slot antenna, when mounted horizontally, has an antenna response pattern similar to that of a vertical $\lambda_0/4$ antenna for a vertically polarised radio signal, and has a bandwidth of about 3%. At 500

MHz, this would give a useful bandwidth from 493 MHz to 507 MHz. Although this is too narrow for many applications, such as cellular radio communication, such a bandwidth is adequate for communication between a utility meter site and a base station which may take place, for example, for a few seconds once per day, week or month.

The slot antenna has the particular advantages of a low profile, omnidirectional response pattern in the azimuthal plane, and compact size for a given wavelength. The circular symmetry of the slot antenna is also advantageous because many types of utility cover plate are disc-shaped, in which case the slot antenna may extend substantially concentrically around the disc.

In this case, a battery may also be disc shaped and may additionally be concentrically spaced within the inner radius of the slot.

The slot antenna ground plane may be provided separately of the cover plate, for example in use being affixed to a lower surface of the cover plate. Preferably, however, the ground plane is provided within the cover plate, for example being either adjacent to a first, lower side of the cover plate or by the lower side of the cover plate itself. The slot antenna may then have a ring which is substantially coplanar with a second upper side of the disc.

In general, objects surrounding an antenna will effect the antenna response pattern. The slot antenna may be substantially coplanar with the surface of the surrounding earth, and this does effect the ability of such an antenna to communicate with a base station, particularly when the

ground is wet. The ground will attenuate the antenna response, as well as detune or shift the antenna frequency. It is possible, however to accommodate such effects by the use of an efficient radiator such as a slot antenna, and by appropriate compensation in the design of the antenna.

In order to transmit or to relay meter readings from the meter, the radio communication device may have a communication link between the antenna and the meter by which the antenna may be fed with a signal representative of a meter reading. The communication link may optionally be bidirectional so that other signals, for example a polling signal from the remote unit or an interrogation or enquiry signal from circuitry in the cover plate, may be communicated from the antenna or cover plate to the meter. References herein to communication between the antenna or cover plate and meter therefore encompass both the case where such communication is purely unidirectional, ie from the meter to the antenna or cover plate, and also cases where such communication is bidirectional.

The communication link may be a local radio communication link in the recess between matched antennas in the meter and the cover plate. The communication link may alternatively be a fibre optic link. However, it is preferred if the communication link comprises a transmission line connected to the antenna, being either directly wired to the antenna, or indirectly wired through intervening electronics, such as an rf amplifier or any other analog or digital circuitry. The transmission line may then, in use, extend from the cover plate towards the meter. Examples of suitable transmission line include coaxial cable, and parallel and twisted pair wires.

Because a meter may be immersed in water seeping from the ground, meter casings generally comprise a sealed housing. It is therefore desirable to limit as far as possible the number and extent of any seals or changes of material in the casing. For example, a conventional water meter may have a casing made in two parts with apertures in the casing only for a water pipe entrance and exit, and a small window for manual reading of meter digits. It is therefore preferable if the communication link has coupling means, such as electromagnetic coupling means, for non-invasive communication with the meter, so that the transmission line may non-invasively communicate with the meter through the housing.

In this sense, non-invasive means are those which do not penetrate through the casing with, for example, a coaxial connector extending from the inside to the outside of the casing. Apart from avoiding the need for additional seals, this also addresses the problem of corrosion between electrical contacts.

Examples of electromagnetic coupling include: inductive coupling, for example*p1098means of an rf transformer arrangement with primary and secondary coils, one coil inside and the other coil outside the housing; or optical coupling, for example with at least one LED transmitter-receiver pair either side of a window in the housing. Two such pairs could be used for bidirectional communication through the transmission line to the meter.

Inductive coupling may be used over the frequency range of about 10 Hz to about 100 kHz.

Another example of electromagnetic coupling would be to have a visible or infrared optical source on the outside

of the housing, which illuminates a meter dial or other optically detectable means, for example a bar code, inside the meter housing. An optical detector, for example a linear or two-dimensional charge coupled device (CCD) array, could then be positioned outside the meter housing and arranged to collect and resolve the light returned from the optically detectable means. In order to conserve power from the battery in the meter pit lid, it would be preferable if such an optical source and detector were energised only periodically. An advantage of this approach is that there is no need for any electronics or electrical power storage means (eg a battery or capacitor) to be incorporated within the meter unit. Such an arrangement may therefore be used with standard or near-standard utility meters, or retrofitted to existing meter installations.

An example of non-electromagnetic coupling means, would be to use an acoustic transducer, for example a piezo transducer, to communicate information or meter readings from within the utility meter to an acoustic receiver or microphone. The signal from the acoustic receiver would then preferably be converted into an electrical signal for onward transmission to the cover plate.

In one embodiment of the invention, the electromagnetic coupling is inductive coupling (effectively, localised radio transmission) in which the meter has a "local primary" antenna, for example either a slot antenna or a loop antenna, which is coupled to the coupling means, which may then be "local antenna" such as a loop outside the housing. Although the local primary antenna and coupling loop are on opposite sides of the meter housing, the loop is preferably in close proximity with the slot antenna for greater coupling efficiency. In a preferred

embodiment, the coupling loop may be inside the perimeter of the local primary loop antenna.

Since the local primary antenna is provided within the housing, for example an inner surface of the housing, the primary antenna is protected from the external environment. Since the housing may have a window, for example for manual meter readings, the local primary antenna may be disposed around the window. The local primary antenna may also be affixed to the window, for example being glued to or plated on the window, or alternatively being laminated within the window. Otherwise, at least some other portion of the housing having the local primary antenna must be substantially transparent to electromagnetic radiation at the frequencies employed for communication through the housing.

The coupling means are preferably removably attachable to the housing, so that the cover plate may removed from the recess, for example to recharge or replace the battery, without disturbing the utility meter.

Means may be provided to reliably and repeatably mount or otherwise affix the coupling means to the meter, for example with surfaces that mate between the coupling means and the meter. In this regard, the window may have a frame with a feature adapted to seat and align with a matching feature of the coupling means to ensure a repeatable alignment between the coupling means and, for example, a meter dial or the local primary antenna around or in proximity with the window.

The utility meter may have means for storing electrical energy (for example a capacitor or a rechargeable battery)

which may be recharged by electrical power transmitted from the coupling means to power receiver means inside the housing. The power receiver means within the housing may be the local primary antenna, or it may be the one of a pair of low-frequency or rf transformer coils. The utility meter may then receive electrical power from the battery in the cover plate, for example only periodically whenever it is desired to make a meter reading. The electrical power would preferably then be converted in a dc to ac converter in the lid and then transmitted to the coupling means or a transformer primary winding. The use of a rechargeable storage means within the utility meter housing provides two important advantages. Firstly, this addresses the problem of having to access and open a utility meter, for example every few years, to change a battery. Secondly, the act of recharging the battery may be used as a trigger to initiate a meter reading from within the utility meter.

The communication link may be a local radio communication link in the recess between a local primary antenna in the meter and a matched local antenna which is either in the cover plate, or alternatively outside the cover plate and near or on the meter and connected to the cover plate by a transmission line. The term "local" is used herein to distinguish an antenna in the cover plate, or elsewhere in the recess, used for local communication with the meter for onward transmission by the main antenna in the cover plate.

In order to power a local radio communication link from the local primary antenna in the meter to the local antenna, or to power inductive coupling from inside to outside the housing, the utility meter may have means for storing electrical energy (for example a capacitor or a

rechargeable battery) which may be recharged by electrical power transmitted non-invasively through the housing to power receiver means inside the housing. Such non-invasive power transmission may be transmitted from the coupling means to the local primary antenna.

The power transmission may, however, be more efficient if the coupling is by way the primary and secondary windings of the rf transformer. There may therefore be a separate rf transformer and local primary antenna or coupling means to charge a battery or capacitor in the utility meter. Then the efficiencies may be independently optimised for both the power transmission and the radio or inductive communication.

It may, however, be possible within the confines of the meter, to provide a battery which is not rechargeable in situ but which has sufficient capacity such that the battery may only need to be replaced every five or ten years.

The invention will now be described by way of example and with reference to the accompanying drawings, in which:

Figure 1 is a side view in partial cross-section of a radio communication device and utility metering device according to the invention, showing a cover plate and utility meter;

Figure 2 is a top plan view of the cover plate of Figure 1; and

Figure 3 is a top plan view of the utility meter of Figure 2.

The drawings show orthogonal axes x, y and z. Axes x and y are in the azimuthal plane, parallel to the horizon, and the elevation plane is any plane parallel to the z axis, which defines vertical.

Referring first to Figures 1 and 2, a utility metering device generally indicated at 10 consists of: a utility meter 12 housed in a recess 14, here a meter pit, in the ground 16; and a radio communication device generally indicated at 18 comprising a disc-shaped meter cover plate 20 which covers the meter pit 14 and which has one slot antenna generally indicated at 22 for radio communication of meter readings from the meter 12 to a remote meter reading unit (not shown).

The slot antenna 22 is sealed within the disc-shaped meter cover plate 20 along with a disc-shaped sealed antenna electrical unit 50. Although not illustrated, the antenna electrical unit 50 contains a rechargeable battery, and receive and transmit circuitry for radio communication with the remote meter reading unit and for communication with the utility meter 12.

The slot antenna 22 has a conducting horizontal, annular slot-ring 24 and a conducting circular ground plane 26 which is parallel to and disposed below the slot-ring. The ground plane 26 extends as far as the outer annular edge of the slot-ring 24 but could extend beyond the edge of the slot-ring so increasing the efficiency of the slot antenna.

Although not illustrated, the slot-ring 24 and ground

plane 26 could be plated on parallel printed circuit boards spaced apart and held in a solid construction by one or more dielectric layers. The slot-ring 24 is electrically connected to the ground plane by a VIA 28, perpendicular to the ring and ground plane at a ground point 30.

The slot-ring 24 also has a slot feed point 32, which is in this example spaced optimally at a circumference of about 5° of free-space wavelength from the ground point 30.

The feed point 32 of the slot-ring is designed to be fed by a low impedance TEM (transverse electric and magnetic) unbalanced transmission line with, for example, an impedance of 50 Ω. In this example, the feed point 32 is wired through the antenna electrical unit 50 to a core conductor 34 of a shielded coaxial cable generally indicated at 36. The core conductor passes through a bore 38 through the ground plane 26 and any intervening dielectric and into the antenna electrical unit 50. Shielding 40 of the cable 36 is grounded to the ground plane 26 next to the bore 38 so as to be nearly directly below the feed point 32.

It is often the case that manufacturing tolerances will result in different antenna units having a slot antenna 22 with slightly different resonant frequencies. Such variations can be accommodated if the slot-ring 24 comprises a tuning capacitor generally indicated at 42 at a point on the slot-ring directly opposite the ground point 30. The exact location of the capacitor on the ring has a bearing on the sensitivity of the resonant frequency of the ring to the value of capacitance. If the connection of the capacitance is offset from the directly

opposite ground point position, then less frequency change is induced for a given capacitance. This is a useful feature in a manufactured item.

This capacitor can take one of several forms, and as shown in Figure 2 is a rectangular conducting section 44 connected by a narrow neck 46 to the outer edge of the slot-ring 24. The area of the capacitor is trimmed along an edge, for example by a laser, and as indicated by a dashed line 48 in order to tune the resonant frequency of the slot-ring 24 to the desired value.

Another design of variable capacitor, not shown in the drawings, is a grounded conducting plate between the slot-ring and the ground plane that can be moved to adjust the separation between the plate and slot-ring. A further way of varying the capacitance between these layers would be to insert or withdraw a section of dielectric called a dielectric puck.

The capacitance can also be changed by means of electronic switching, that is, by turning on or off PIN diodes connected to capacitor sections. This method of changing the resonance frequency and/or the matching, is applicable on transmit and receive. For low power transmit and for receive it is also possible to tune the resonance of the antenna by means of the capacitance provided by varying the bias voltage applied to reverse biased capacitance diodes.

The slot-ring 24 of the slot antenna 22 typically has a circumference of up to $\lambda_0/2$, where λ_0 is the free-space wavelength of the radio wave. The impedance of the slot antenna depends on a number of factors such as the width of the conductor forming the ring and its height above the

ground plane 26, taking into account also any dielectric between the slot-ring and the ground plane. In the embodiment shown in Figures 1 and 2, the circumference of each slot-ring is about 163° of free-space wavelength. At 1 GHz, the circumference is then 136 mm (diameter 43.2 mm). If the slot dielectric were replaced by air, the spacing of the slot-ring above the ground plane would optimally be about 8°, which at 1 GHz is 6.7 mm. For a slot dielectric formed from alumina with a relative permittivity $\epsilon_R = 10$, the spacing would be about 2.5°, or 2.1 mm.

Alternatively, a loop antenna (not illustrated) may be used. A resonant loop antenna may be $\leq\lambda_0/4$ electrical length, or it may be operated in a $\lambda/2$ or a λ mode (depending on the available circumference). In the latter two cases, the antenna far field pattern in the azimuthal plane is lobed, that is, directional. A loop antenna may be fed in a conventional manner, for example, with a feed loop smaller in circumference than the loop antenna lying parallel to, but not co-planar, and within the circumference of the loop antenna.

Although not illustrated, it is possible to broaden the frequency response of the slot antenna 22 by adding a parallel slot-ring having differing inner and outer ring diameters. These rings would share common ground points and common feed points. The effect on the slot antenna of two parallel and electrically connected slot-rings would be to broaden the frequency response of the slot antenna by a factor of about 1.5 to 2, that is, up to a value of about 6%. More parallel slot-rings may be added to broaden further the frequency response. Such slot-rings may conveniently be formed on the surfaces of circuit boards in a multilayer laminated construction. The

inner and outer diameters and widths of the slot-rings will not be the same, but will generally decrease for each lower slot-ring in the construction. The resonant frequency for each slot-ring on its own is chosen to be within 3% of another slot-ring, so that each slot-ring in the multilayer slot-ring structure is resonantly coupled to broaden the frequency response of the slot antenna as a whole.

Considering now the rest of the utility metering device 10 in more detail, the cover plate 20 is seated on an annular ledge 52 defined by a step in an otherwise cylindrical concrete sleeve 54 set into the ground 16. The top of the concrete sleeve 54 is flush with the level of the ground 16 and with the top of the cover plate 20. In use, the cover plate would be secured to a feature in the sleeve with a key operated lock (not shown).

On the lower surface of the cover plate 20, two electrical contacts 51,53 are provided for recharging the rechargeable battery within the cover plate.

Referring now also to Figure 3, the utility meter 12 may be a gas, water or electricity meter, and has a water-tight housing 56 connected to an inlet 58 and an outlet 60 of a service pipe or duct for the transmission of gas, water or electricity. The top of the meter 12 has a glass window 62 through which a meter dial (not shown) may be manually read.

The meter contains a meter electrical unit 64. Although not illustrated, the meter electrical unit 64 contains a non-rechargeable battery, receive and transmit circuitry for communication with the radio communication device 18. If the battery were rechargeable, then the electrical unit

64 would additionally contain and rectification and smoothing circuitry by which a recharging current could be supplied to the battery.

The meter window 62 is drawn as being generally square, but may be any other convenient shape, for example circular or rectangular. The inside surface of the window 62 has plated around its periphery a layer of conducting material defining an open loop 66, referred to hereinafter as the inner loop. The inner loop has opposed ends 68,70 wired to a coaxial conductor 72, one of the ends 68 being connected to a conductor and the other end 70 being connected to shielding. The other end of the coaxial conductor 72 is wired to the meter electrical unit 64.

Towards one side of the inner loop 66, another open loop, referred to hereinafter as the outer loop 74, is mounted on the outside of the utility meter 12. The antenna electrical unit 50, coaxial cable 36 transmission line and outer loop 74 form a communications link between the utility meter 12 and the slot antenna 22. The outer loop 74 provides electromagnetic coupling with the inner loop 66 for non-invasive communication with the meter.

The outer loop 74 of the illustrated embodiment is encased in a plastic clip 76 which has an aperture 78 to receive a stud 80 on the outside of the meter housing 56, in order to clip the plastic clip onto the housing. This arrangement ensures that the inner and outer loops 66,74 are held in the correct alignment with respect to each other, without the need to disrupt the water-tight meter housing 56.

The clip 76 permits rapid and easy removal of the coaxial transmission line 36 when the cover plate has to be

removed from the meter pit 14, for example when the radio communication device needs to be serviced or recharged.

The operation of the radio communication device 18, and the utility metering device 10 in particular may now be appreciated from the following description. A remote meter reading unit may poll the radio communication device 18, for example by sending a radio signal comprising a unique identification code. In order to conserve battery power, the radio communication unit may only be active to receive a polling signal at certain times, for example, within a duty cycle of 10%, such as during one second of every ten seconds. A received signal is then passed from the slot antenna 22 to the antenna electronic unit 50, which may then compare the received identification code with one stored in a read only memory.

If the received identification code matches the stored identification code, then the antenna electronic unit 50 may send an enquiry signal through the coaxial cable 36 transmission line to the outer loop 74. The enquiry signal is then inductively coupled to the inner loop 66.

Because the non-rechargeable battery power supply for the meter electronic unit 64 may have to last for between five and ten years before replacement, the meter electronic unit 64 may be activated to receive the enquiry signal within a duty cycle less than that for the antenna duty cycle, for example 1%, e.g. for one second within every 100 seconds.

Once the enquiry signal is received, the meter electronic unit 64 then transmits inductively a signal representing a meter reading to the outer loop 74 which is then passed by the coaxial cable 36 to the antenna electronic unit,

which then amplifies, or otherwise processes, the meter reading signal for onward transmission to the remote meter reading unit.

The inner loop 66 is in effect a local primary antenna, the slot antenna 22 of the radio communication device 18 then acting as a secondary antenna for onward transmission of meter readings to a remote meter reading unit.

In another embodiment of the invention not illustrated, the local primary antenna in the utility meter is a slot antenna. The ring of such a "meter" slot antenna may be plated on the inner surface of the window, with a ground plane disposed below and parallel to the slot-ring in a manner analogous to that described above for the slot antenna of the cover plate radio communication device.

The radio communication device and the utility metering device as described above may be used in a wide variety of meter reading situations. For example, the recess may not need to be a meter pit in the ground, eg for an electricity or gas meter which may be mounted inside a building, or on an outer wall of a building. In some countries which have severe winters where the ground may freeze to a depth as great as 2 m, water meters may also be mounted inside a building. In such cases, the meter cover plate may be any generally horizontally disposed plate in the vicinity of the meter, for example, joined to a part of the meter housing, or at some distance to the meter housing. The later option may be appropriate if the meter would be shielded by its surrounds, for example metal walls or cladding, or the confines of an underground basement.

Because the battery power source within the utility meter

draws current of a relatively low duty cycle, and does not have to supply the power required for onward transmission to a remote meter reading unit, the utility meter may be left in place for up to ten years before the non-rechargeable battery of the meter electronic unit has to be replaced. Furthermore, the water-proof housing of the utility meter is not compromised by the use of non-standard materials or of cables or electrical connectors penetrating the meter casing. These features permit the utility meter to be left in place for many years, even in the environment of a meter pit flooded with water.

The recess cover plate may then be periodically removed for servicing or for recharging of the rechargeable battery since the non-invasive inductive coupling clip may readily be removed from the utility meter housing.

Claims

1. A radio communication device for remote reading of a meter, comprising a cover plate for covering a recess in which the meter may be held, the cover plate having: at least one antenna for radio communication of meter readings from the meter to a remote reading unit; and a battery for supplying power to a radio transceiver.

2. A radio communication device as claimed in Claim 1, in which the cover plate has a radio transceiver.

3. A radio communication device as claimed in Claim 1 or Claim 2, in which the antenna is disposed around the battery.

4. A radio communication device as claimed in any preceding claim, in which the battery is rechargeable.

5. A radio communication device as claimed in Claim 4, in which terminals are provided for recharging the battery on a surface of the cover plate disposed in use downwards.

6. A radio communication device as claimed in any preceding of claim, in which the cover comprises thermal insulation to thermally insulate the battery.

7. A radio communication device as claimed in any preceding claim, in which the antenna is a slot antenna.

8. A radio communication device as claimed in Claim 7, in which the cover plate is disc-shaped, the slot antenna extending substantially concentrically around the disc.

9. A radio communication device as claimed in any preceding claim, in which the cover plate has an antenna ground plane.

10. A radio communication device as claimed in Claim 9, in which the ground plane is substantially coplanar with a first side of the disc.

11. A radio communication device as claimed in Claim 10, in which the slot antenna has a ring which is substantially coplanar with a second side of the disc.

12. A radio communication device as claimed in any preceding claim, in which the device has a communication link by which the antenna may be fed with a signal representative of a meter reading.

13. A radio communication device as claimed in Claim 12, in which the communication link comprises a transmission line connected to the antenna.

14. A radio communication device as claimed in Claim 12 or Claim 13, in which the communication link has electromagnetic coupling means for non-invasive communication with the meter.

15. A utility metering device that may be read remotely, comprising a utility meter for installation in a recess, and a radio communication device as claimed in any preceding claim, the radio communication device being arranged to communicate meter readings from the meter to the remote unit.

16. A utility metering device as claimed in Claim 15 when

appendant to Claim 13, in which the meter has a sealed housing and the device has electromagnetic coupling means by which the transmission line may non-invasively communicate with the meter through the housing.

17. A utility metering device as claimed in Claim 16, in which the meter has a local primary antenna which is coupled to the coupling means.

18. A utility metering device as claimed in Claim 17, in which the local primary antenna is a slot antenna, and the coupling means is a loop.

19. A utility metering device as claimed in Claim 17, in which the local primary antenna is a loop antenna, and the coupling means is a loop.

20. A utility metering device as claimed in any one of Claims 17 to 19, in which the local primary antenna is provided on an inner surface of the housing.

21. A utility metering device as claimed in Claim 20, in which the housing has a window and the local primary antenna is disposed around the window.

22. A utility metering device as claimed in Claim 21, in which the local primary antenna is affixed to the window.

23. A utility metering device as claimed in any one of Claims 16 to 22, in which the coupling means may be removably attached to the housing.

24. A utility metering device as claimed in any one of Claims 16 to 23, in which the meter has means for storing

electrical energy, said means being rechargable by electrical power transmitted from the coupling means to the local primary antenna.

25. A radio communication device substantially as herein described with reference to or as shown in the accompanying drawings.

26. A utility metering device substantially as herein described with reference to or as shown in the accompanying drawings.

The Patent Office

29

Application No: GB 9711596.8
Claims searched: 1-26

Examiner: Mike Davis
Date of search: 6 May 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): G4H (HNEC, HNEE, HNEL, HNEM, HNNA, HNHE)

Int Cl (Ed.6): G08C, H04Q

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2273593 A	(DYNAMIC SIGNAL PROCESSING) especially Fig.3	1 at least
X	GB 1384598	(ABOYNE) especially page 2 lines 93-106	"
X	GB 1381734	(BALDWIN)	"
X	GB 1343759	(NORTHERN ILLINOIS GAS)	"
X	WO 93/04451 A1	(DISYS)	"
X	WO 87/04275 A1	(AUDITEL)	"
X	US 5617084	(SEARS) especially Fig.9	"
X	US 5583492	(NAKANISHI ET AL)	"

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.